



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

parisons of this background with the photosphere, photographed with light from the continuous spectrum immediately adjoining the calcium, hydrogen, or iron line employed for the flocculi.

These new applications of the spectroheliograph have only recently occurred to me, and are mentioned because of their suitability for use with instruments containing prisms of ordinary height, capable of photographing only narrow zones of the solar image. Numerous other problems might be mentioned, such as the comparative study of H_1 , H_2 , and H_3 photographs, and of calcium, hydrogen, and iron images; the distribution of the flocculi in latitude and longitude; their varying area, as bearing on the solar activity and on terrestrial phenomena; and their motion in longitude, as measuring solar rotation. But limitations of time forbid more than a mere reference to work and methods the details of which are discussed elsewhere. My purpose has been accomplished if I have shown that with comparatively simple instrumental means any careful observer may secure important results. In much of this work it is desirable that investigators occupied with similar problems should co-operate with one another. The International Union for Co-operation in Solar Research was organized with this end in view. It has already inaugurated solar studies on a common plan in several different fields, and is preparing to extend the range of its activities in the near future.

NOTE ON THE DISTRIBUTION OF DOUBLE STARS
IN THE ZONE $+56^\circ$ TO $+90'$.¹

BY R. G. AITKEN.

The main object of the survey of the sky that has been in progress at the Lick Observatory for the past seven years is to accumulate data for a statistical study of the number and the distribution in space of the double stars whose combined magnitude is brighter than 9.1 of the B. D. scale, and whose angular separation is less than $5''$. This survey is now well advanced toward completion, so far as the sky area

¹ Read before the Astronomical and Astrophysical Society of America, New York, December, 1906.

north of -22° Declination is concerned, and it becomes a matter of interest to ascertain what kinds of data it is likely to yield.

In general, the various 4° zones into which the sky was divided for this survey have not yet been completely examined, the winter hours of Right Ascension, from 7^h to 14^h , being considerably less advanced than the remaining portion. But the entire area north of $+56^\circ$ has been examined, and I have tabulated the results. Some of these tabulations and my conclusions based upon them I desire to present briefly.

The region named was divided into eight zones, of which Professor HUSSEY examined four,—namely, $+60^\circ$ to $+64^\circ$, $+64^\circ$ to $+68^\circ$, $+76^\circ$ to $+80^\circ$, $+80^\circ$ to $+84^\circ$, and the writer the remaining four. Professor HUSSEY included the 9.1 B. D. stars in his search, while I examined only those as bright as 9.0. In the following discussion only the stars to 9.0 are included.

As the area north of $+60^\circ$ was almost entirely examined with the 12-inch telescope, while about one half of the zone, $+56^\circ$ to $+60^\circ$, was examined with the 36-inch, the latter is considered separately.

It has been the experience of both observers that, under good conditions, a double star with nearly equal components will be recognized with certainty with the 12-inch telescope if the distance is as great as $0''.25$; in fact, we have each discovered several pairs with that instrument whose distances, measured later with the 36-inch, were found to be well *under* $0''.25$. If the two components differ two or more magnitudes, we cannot be sure to detect the duplicity if the distance is much under $1''$. If the distance is $2''$ or more, a companion as faint as 13 or $13\frac{1}{2}$ magnitude will be seen readily.

Since every previously known double star as bright as 9.0 magnitude was carefully identified in the course of the search, the fact that they were first seen with telescopes of very different apertures has no bearing upon the present discussion, so that the results given for the zone $+60^\circ$ to $+90^\circ$ may be considered to be based entirely upon the separating power of the 12-inch telescope.

By actual count of the stars on the charts used in the search, I find that in the region north of $+60^\circ$ we have examined 12,299 stars of 9.0 magnitude or brighter. Of these, 294 were

known double stars, and 259 more were found to be double during our survey, giving a total of 553 pairs in this sky area. This includes seven bright stars with distances exceeding 5", and excludes duplicates. That is, when we have found that one component of a Struve or other known pair is itself double only the closer pair is counted.

It appears, then, that one star in $22\frac{1}{4}$ in this region is a close double within the separating power of a good 12-inch telescope, a ratio somewhat smaller, as I have reason to believe, than will be found to hold for the sky in general. The tables that accompany this note exhibit the distribution of these pairs. Table I gives the number of new discoveries and the number of previously known double stars in each zone and for each six hours of Right Ascension. Table II combines the new and old pairs for each hour of Right Ascension for the whole region and for the two zones $+60^\circ$ to $+68^\circ$ and $+68^\circ$ to $+90^\circ$ separately.

TABLE I. $+60^\circ$ TO $+90^\circ$.

Zone.	Double Stars.			Stars to 9.0 Mag.	Ratios.	
	New.	Old.	Total.		New D. S. to 9.0 Stars.	D. Stars to 9.0 Stars.
84° to 90°	0	4	4	107	I :	I : 26.8
80 to 84	2	5	7	193	I : 96.5	I : 26.2
76 to 80	7	10	17	330	I : 47.2	I : 19.4
72 to 76	14	10	24	418	I : 29.9	I : 17.4
68 to 72	11	12	23	574	I : 52.2	I : 23.0
64 to 68	21	21	42	691	I : 33.0	I : 16.5
60 to 64	25	31	56	1041	I : 41.6	I : 18.6
QUADRANT II. 6^h TO 12^h .						
84° to 90°	3	0	3	110	I : 36.7	I : 36.7
80 to 84	4	3	7	193	I : 48.2	I : 27.6
76 to 80	2	2	4	281	I :	I : 70.2
72 to 76	6	7	13	337	I : 56.2	I : 25.9
68 to 72	5	7	12	405	I : 81.0	I : 33.8
64 to 68	10	12	22	519	I : 51.9	I : 23.6
60 to 64	12	14	26	639	I : 53.2	I : 24.6
QUADRANT III. 12^h TO 18^h .						
84° to 90°	1	3	4	130	I :	I : 32.2
80 to 84	2	5	7	191	I : 95.5	I : 27.3
76 to 80	5	3	8	288	I : 57.6	I : 36.0
72 to 76	5	4	9	372	I : 74.4	I : 41.1
68 to 72	10	7	17	461	I : 46.1	I : 27.1
64 to 68	12	6	18	545	I : 45.4	I : 30.3
60 to 64	12	11	23	610	I : 50.8	I : 26.5

QUADRANT IV. 18^h TO 24^h.

Zone.	Double Stars.			Stars to 9.0 Mag.	Ratios.	
	New.	Old.	Total.		New D. S. to 9.0 Stars.	D. Stars to 9.0 Stars.
84° to 90°	2	2	4	117	1 : 58.5	1 : 29.2
80 to 84	3	7	10	219	1 : 73.0	1 : 21.9
76 to 80	9	6	15	328	1 : 36.4	1 : 21.9
72 to 76	15	12	27	412	1 : 27.5	1 : 15.3
68 to 72	14	16	30	587	1 : 41.9	1 : 19.6
64 to 68	21	21	42	965	1 : 46.0	1 : 23.0
60 to 64	26	53	79	1236	1 : 47.5	1 : 15.6

SUMMARY.

Quadrant	I	80	93	173	3354	1 : 41.9	1 : 19.4
	II	42	45	87	2484	1 : 59.1	1 : 28.6
	III	47	39	86	2597	1 : 55.3	1 : 30.2
	IV	90	117	207	3864	1 : 42.9	1 : 18.7
Total		259	294	553	12299	1 : 47.5	1 : 22.24

TABLE II.

RATIOS OF DOUBLE STARS TO STARS 9.0 OR BRIGHTER, BY HOURS OF R. A.

R. A.	Zone + 60° to + 90°.	Zone + 68° to + 90°.	Zone + 60° to + 68°.
0 ^h	28 : 624 = 1 : 22.3	12 : 262 = 1 : 21.6	16 : 362 = 1 : 22.6
1	33 : 644 = 1 : 19.5	18 : 278 = 1 : 15.4	15 : 366 = 1 : 24.4
2	29 : 611 = 1 : 21.1	13 : 293 = 1 : 22.5	16 : 318 = 1 : 19.9
3	27 : 547 = 1 : 20.3	8 : 275 = 1 : 34.4	19 : 272 = 1 : 14.3
4	31 : 497 = 1 : 16.0	13 : 277 = 1 : 21.3	18 : 220 = 1 : 12.2
5	25 : 431 = 1 : 17.2	11 : 237 = 1 : 21.5	14 : 194 = 1 : 13.9
6	11 : 439 = 1 : 39.9	6 : 226 = 1 : 37.7	5 : 213 = 1 : 42.6
7	14 : 432 = 1 : 30.9	6 : 239 = 1 : 39.8	8 : 193 = 1 : 24.1
8	16 : 411 = 1 : 25.7	5 : 211 = 1 : 42.2	11 : 200 = 1 : 18.2
9	19 : 416 = 1 : 21.9	13 : 221 = 1 : 17.0	6 : 195 = 1 : 32.5
10	10 : 394 = 1 : 39.4	3 : 211 = 1 : 70.3	7 : 183 = 1 : 26.1
11	17 : 392 = 1 : 23.1	6 : 218 = 1 : 36.3	11 : 174 = 1 : 15.8
12	9 : 375 = 1 : 41.7	7 : 220 = 1 : 31.4	2 : 155 = 1 : 77.8
13	11 : 414 = 1 : 37.6	6 : 226 = 1 : 37.7	5 : 188 = 1 : 37.6
14	10 : 375 = 1 : 37.5	6 : 190 = 1 : 31.7	4 : 185 = 1 : 46.2
15	21 : 462 = 1 : 22.0	7 : 260 = 1 : 37.1	14 : 202 = 1 : 14.4
16	16 : 480 = 1 : 30.0	9 : 268 = 1 : 29.8	7 : 212 = 1 : 30.3
17	19 : 491 = 1 : 25.8	10 : 268 = 1 : 26.8	9 : 223 = 1 : 24.8
18	25 : 524 = 1 : 21.0	13 : 272 = 1 : 20.9	12 : 252 = 1 : 21.0
19	24 : 650 = 1 : 27.1	10 : 259 = 1 : 25.9	14 : 391 = 1 : 29.4
20	25 : 557 = 1 : 22.3	11 : 257 = 1 : 23.4	14 : 300 = 1 : 21.4
21	43 : 696 = 1 : 16.2	13 : 248 = 1 : 19.1	30 : 448 = 1 : 14.9
22	44 : 686 = 1 : 15.6	18 : 319 = 1 : 17.7	26 : 367 = 1 : 14.1
23	46 : 751 = 1 : 16.3	21 : 308 = 1 : 14.7	25 : 443 = 1 : 17.7

Quadrant.	SUMMARY.					
I	173 : 3354 = 1 : 19.4	75 : 1622 = 1 : 21.6	98 : 1732 = 1 : 17.7			
II	87 : 2484 = 1 : 28.6	39 : 1326 = 1 : 34.0	48 : 1158 = 1 : 24.1			
III	86 : 2597 = 1 : 30.2	45 : 1432 = 1 : 31.8	41 : 1165 = 1 : 28.4			
IV	207 : 3864 = 1 : 18.7	86 : 1663 = 1 : 19.3	121 : 2201 = 1 : 18.2			
Total	553 : 12299 = 1 : 22.24	245 : 6043 = 1 : 24.7	308 : 6256 = 1 : 20.3			

It is at once apparent from these tables that the double-star distribution follows in a general way the distribution of all stars to 9.0 magnitude, and if the numbers in Table II are plotted the resemblance of the curves is striking.

But an unexpected feature of the distribution is the fact that the double stars are *relatively as well as absolutely more numerous in the richer sky areas*, the numbers in the four quadrants of Right Ascension being very nearly as 2 to 1 to 1 to 2.4 while the numbers of the stars to 9.0 magnitude are about as 1.3 to 1 to 1 to 1.5. When the zones $+60^\circ$ to $+68^\circ$ and $+68^\circ$ to $+90^\circ$ are taken separately the same relation is found in each.

My next effort was to determine whether a different relation would be shown by the closer pairs or by the brighter pairs. The pairs under $2''$ were separately tabulated, then those under $1''$, then the very close pairs, $\frac{1}{3}''$ or less, and finally the pairs as bright as 7.5 magnitude. It is not necessary to give the details, but the results by quadrants are as follows:—

	No.	I. Ratio.	No.	II. Ratio.	No.	III. Ratio.	No.	IV. Ratio.
Under $\frac{1}{3}''$	15	1 : 224	9	1 : 276	11	1 : 236	24	1 : 161
“ 1	76	1 : 44	37	1 : 67	40	1 : 65	80	1 : 48
“ 2	113	1 : 30	56	1 : 44	66	1 : 39	132	1 : 29
“ 5	173	1 : 19	87	1 : 29	86	1 : 30	207	1 : 19
7.5 Mag. or brighter	49	1 : 68	23	1 : 108	18	1 : 144	63	1 : 61

It is clear from an inspection of this table that the closer pairs, which may safely be classed as binary systems, follow the same general law of distribution as do all the pairs here considered, and also that magnitude does not materially affect the question. In fact, I find that the average magnitude of the closer pairs in the second and third quadrants is slightly greater, numerically, than that of the corresponding pairs in the other two. So far as this factor goes, therefore, rather more difficult pairs were detected in the second and third quadrants than in the first and fourth. The result is not

affected by the time of year in which the work was done, as only nights of good seeing were used, and, besides, the search in each quadrant extended over from six to nine months.

It may therefore be accepted as a fact that in the sky area from $+60^\circ$ to the North Pole, *double stars of all classes up to 5" separation are relatively more numerous in the region richest in stars to 9.0 magnitude*,—that is, in the region of the Milky Way.

The zone $+56^\circ$ to $+60^\circ$ contains 4,257 stars as bright as 9.0 that were actually examined with the telescope. The fourth quadrant was almost wholly surveyed with the 12-inch, the first with the 36-inch, and the other two about in equal parts with the two telescopes. Of these stars 114 were known double stars and 130 more were found to be double, making a total of 244 pairs, or a ratio of 1 to 17.4. When the numbers of double stars and of stars to 9.0 in each hour of Right Ascension are plotted the two curves again show a very marked similarity.

Grouped by quadrants, we find the following relations:—

	Stars to 9.0.	Double stars.	Ratio.
I	1413	98	1 : 14.4
II	716	35	1 : 20.4
III	672	30	1 : 22.4
IV	1456	81	1 : 18.0

Thus in this zone, too, we find that the double stars are relatively more numerous in the regions richest in stars to 9.0 magnitude, though the curve is somewhat affected, as one would expect, by the fact that the fourth quadrant was examined with a much less powerful instrument than the other three, especially the first.

When the ratios are taken by zones of Declination, we find:—

Zone.	Ratio.	Zone.	Ratio.
$+84^\circ$ to $+90^\circ$	1 : 30.9	$+68^\circ$ to $+72^\circ$	1 : 24.7
$+80$ to $+84$	1 : 25.7	$+64$ to $+68$	1 : 21.9
$+76$ to $+80$	1 : 27.9	$+60$ to $+64$	1 : 19.2
$+72$ to $+76$	1 : 21.1	$+56$ to $+60$	1 : 17.4

The charts used in the survey give evidence of local irregularities in the distribution of the double stars, the ratio in some areas of 15 to 20 square degrees being as high as 1 to 7 or 8 and in others as low as 1 to 50. The study of these irregularities is deferred to the time when the whole northern

hemisphere shall have been examined, when a division of the sky into small sections of approximately equal area will make it possible to decide whether there is any marked tendency toward gregariousness on the part of the double stars and also whether, as a whole, they are distributed symmetrically relatively to some plane,—as, for instance, that of the Milky Way.

LICK OBSERVATORY, December 4, 1906.

ASTRONOMICAL OBSERVATIONS IN 1906.

MADE BY TORVALD KÖHL, AT ODDER, DENMARK.

VARIABLE STARS.

Z Cygni.¹

Jan. 20:	$Z = c.$	Aug. 31:	$\begin{cases} < b'. \\ > b. \end{cases}$
Apr. 8:	invisible.	Sept. 8:	$= b.$
14:	$< e.$	19:	id.
22:	id.	24:	id.
May 24:	id.	Nov. 10:	1 step $> e.$
July 26:	$= b.$	13:	1 step $< e.$
Aug. 19:	$\begin{cases} < a. \\ > b'. \end{cases}$	Dec. 4:	3 steps $< e.$
24:	$= b'.$	9:	id.
27:	id.	23:	invisible.

S Ursæ Majoris.²

Jan. 1:	$S = g.$	May 23:	$= e.$
19:	$f'.$	July 26:	invisible.
Feb. 28:	1 step $< e.$	Aug. 19:	$= g.$
Mar. 14:	$= d.$	24:	$\begin{cases} > g. \\ < f. \end{cases}$
19:	id.	Aug. 27:	id.
29:	2 steps $> d.$	31:	id.
Apr. 2:	id.	Sept. 5:	1 step $> f'.$
5:	$\begin{cases} 4 \text{ steps } > d. \\ 9 \text{ steps } < c. \end{cases}$	8:	$\begin{cases} < e. \\ > f'. \end{cases}$
8:	6 steps $> d.$	10:	id.
10:	id.	12:	id.
12:	id.	19:	id.
14:	4 steps $< c.$	21:	1 step $< e.$
22:	id.	23:	id.
May 11:	$= d.$		

¹ Vide the sketch in the *Publications A. S. P.*, No. 100, p. 16.

² Vide the sketch in the *Publications A. S. P.*, No. 73, p. 56.